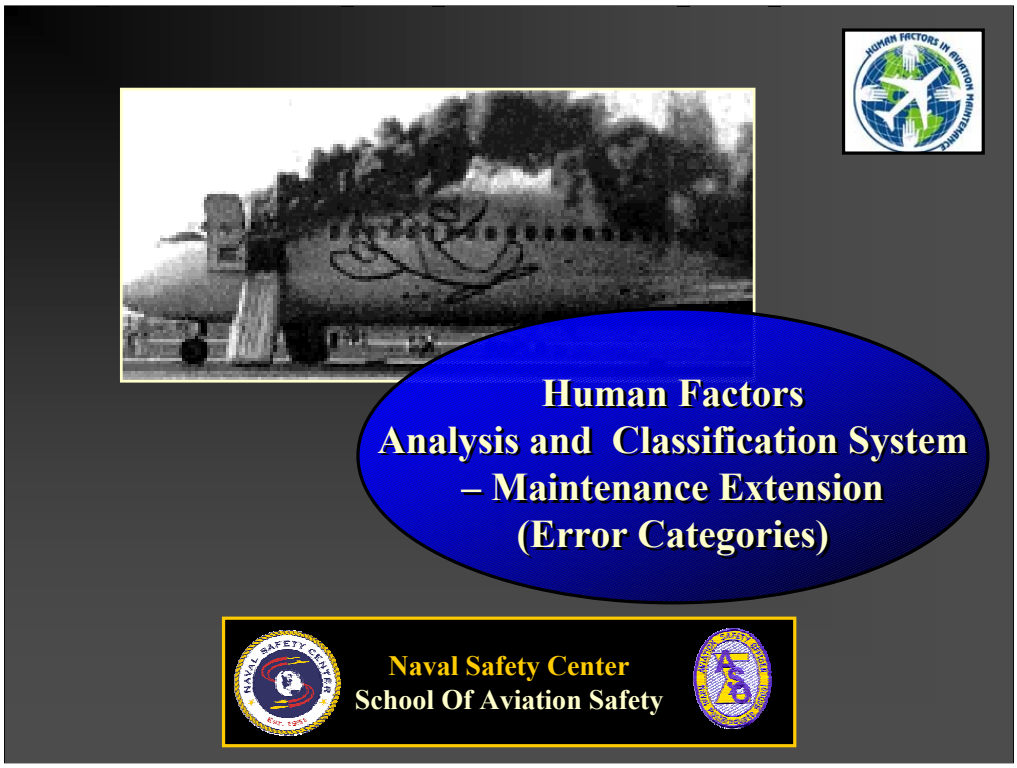


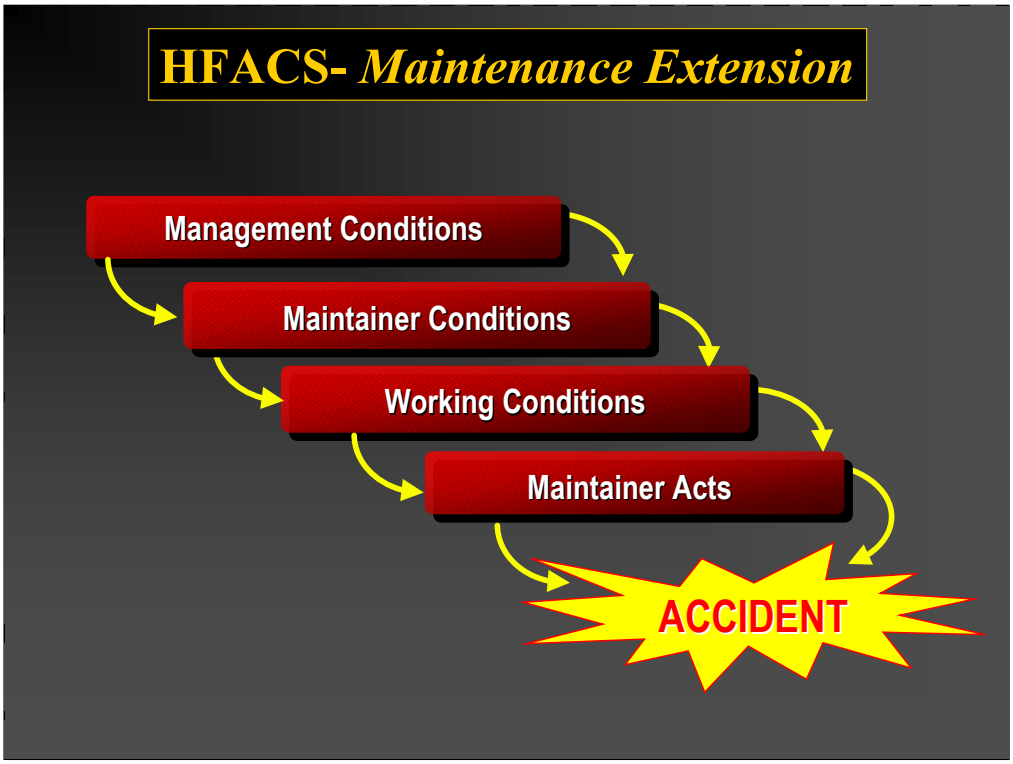
Photo: Value Jet compressor chunk failure with seven injuries: retrieved from FAA's Web based MRM training site at http://hfskyway.faa.gov.

Recommend: Display Motivational Posters/Statements/Articles in the room to support training points and hold students' interest.

Facilitator: Ensure that the students have copies of these presentation slides to use as a reference during the presentation

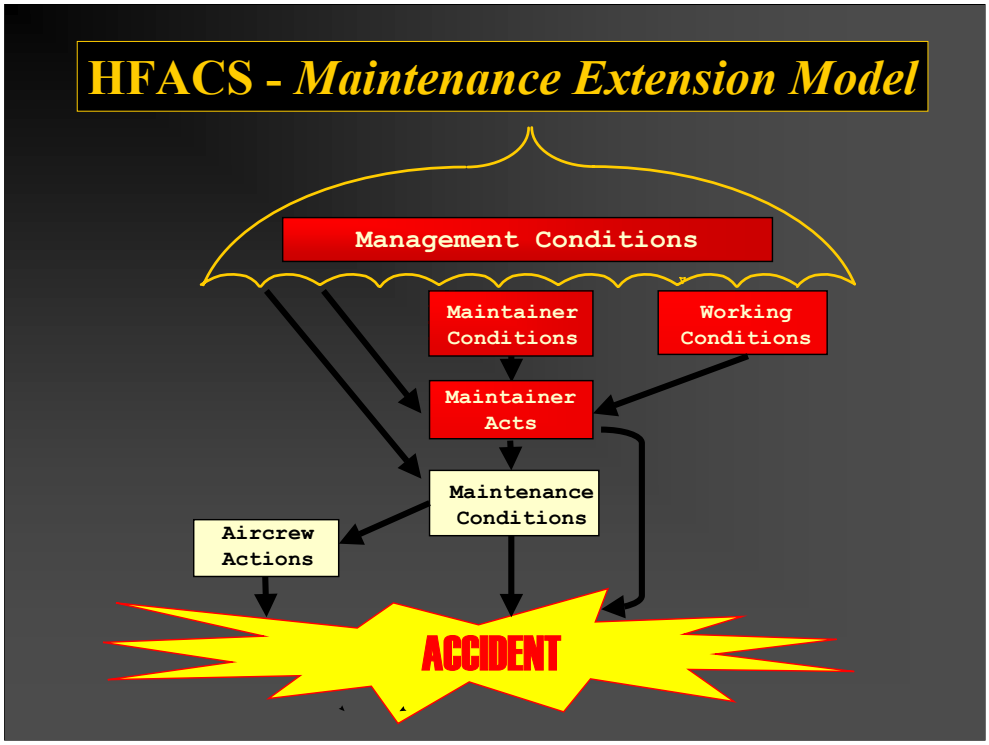
The first presentation explained the rationale and development of the HFACS-ME model. We will now examine the model in greater detail to better understand the individual error categories. Please pay attention to the definitions and ask questions as necessary.

(Presentation time: 1– 1.5 hours)



The Human Factors Analysis and Classification System – Maintenance Extension (HFACS-ME) model provides the means to identify causal factors that were previously overlooked. **HFACS-ME is therefore an important tool to enable us to "think outside of the box".** It will enable an organization to develop and implement new intervention strategies to reduce the mishap rate.

The four categories, or levels, on this slide represent the relationship of latent conditions (**Management**, **Maintainer, and Working**) to the active failure (**Maintainer** act). **These four categories, which should be familiar to you from the first presentation, are the First Order Error Categories of the HFACS Framework**. (quickly go to next slide)



This model provides a realistic example of the interaction between the First Order Error Categories.

Management Conditions, **Maintainer Conditions**, and **Working Conditions** may INDEPENDENTLY or COLLECTIVELY affect the maintainer's actions **(Maintainer Act)**.

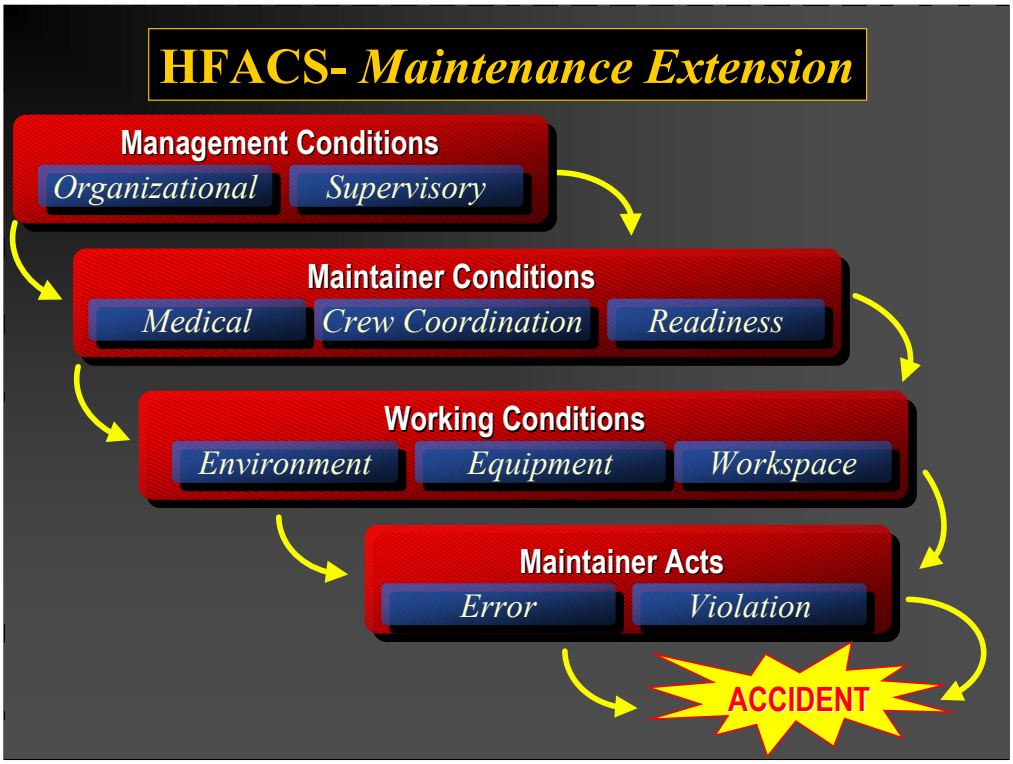
This **Unsafe Maintainer Act** may either:

(1) Lead directly to a mishap or injury (Example: a maintainer runs a forklift into the side of an aircraft and damages it), or

(2) Become a latent **Maintenance Condition**, which the aircrew would have to deal with on take-off, in-flight, or on landing. (Example: an improperly rigged landing gear that collapses on touchdown or an over-torqued hydraulic line that fails in flight and causes a fire)

It is important to note that **Management Conditions** related to design for maintainability, prescribed maintenance procedures, and standard maintenance operations could be inadequate and also lead directly to a **Maintenance Condition.**

Please note that this model utilizes only the First Order Error Categories (again, shown in red). So how do the Second Order Error Categories affect this relationship? (quickly go to next slide)



The HFACS-ME Four First Order Error Categories (shown in red) can be further identified by the Second Order Error Categories (shown in blue).

Management Conditions are established at the **Organizational** level (above your local work station/location, between organizations/manufacturers, or from regulatory agencies), or at your local **Supervisory** levels.

Maintainer Conditions directly impact an individual maintainer and may include **Medical**, **Crew Coordination**, or **Readiness** factors.

Working Conditions that affect one or more maintainers include **Environment**, **Equipment**, and **Workspace** limitations.

Maintainer Acts can either be **Errors** or **Violations.**

Note: Multiple Error Categories may be factors in mishaps. For example, both Organizational and Supervisory practices may combine to form Management Conditions that lead to mishaps, or a combination of Equipment and Workspace conditions may promote an unsafe Working Condition.

Now, as you probably surmised, the Third Order Error Categories are simply a further breakdown of the Second Order Error Categories shown on this slide (go to next slide).

HFACS-ME Framework

Error Categories of HFACS Framework				
First Order	**Second Order**	**Third Order**		
Management Conditions	Organizational	- Inadequate Processes - Inadequate Resources	- Inadequate Documentation	- Inadequate Design
	Supervisory	- Inadequate Supervision - Supervisory Misconduct	- Inappropriate Operations	- Uncorrected Problem
Maintainer Conditions	Medical	- Mental State	- Physical State	- Limitation
	Crew Coordination	- Communication	- Assertiveness	- Adaptability/Flexibility
	Readiness	- Training/Preparation	- Certification/Qualification	- Infringement
Working Conditions	Environment	- Lighting/Light	- Weather/Exposure	- Environmental Hazards
	Equipment	- Damaged/Unserviced	- Unavailable/Inappropriate	- Dated/Uncertified
	Workspace	- Confining	- Obstructed	- Inaccessible
Maintainer Acts	Error	- Attention/Memory - Skill/Technique	- Judgment/Decision-Making	- Knowledge/Rule Based
	Violation	- Routine - Flagrant	- Infraction	- Exceptional

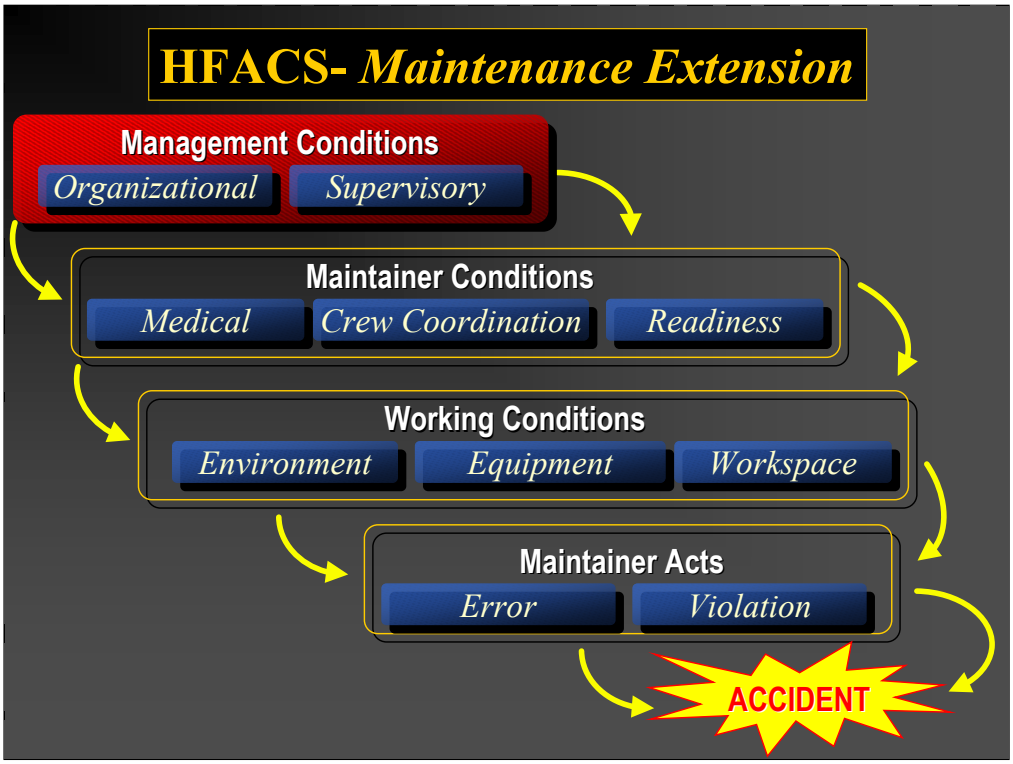
Here again, is the HFACS-ME Framework.

Notice that the **First Order Categories (in Red**) are the same major categories highlighted on the Umbrella Model.

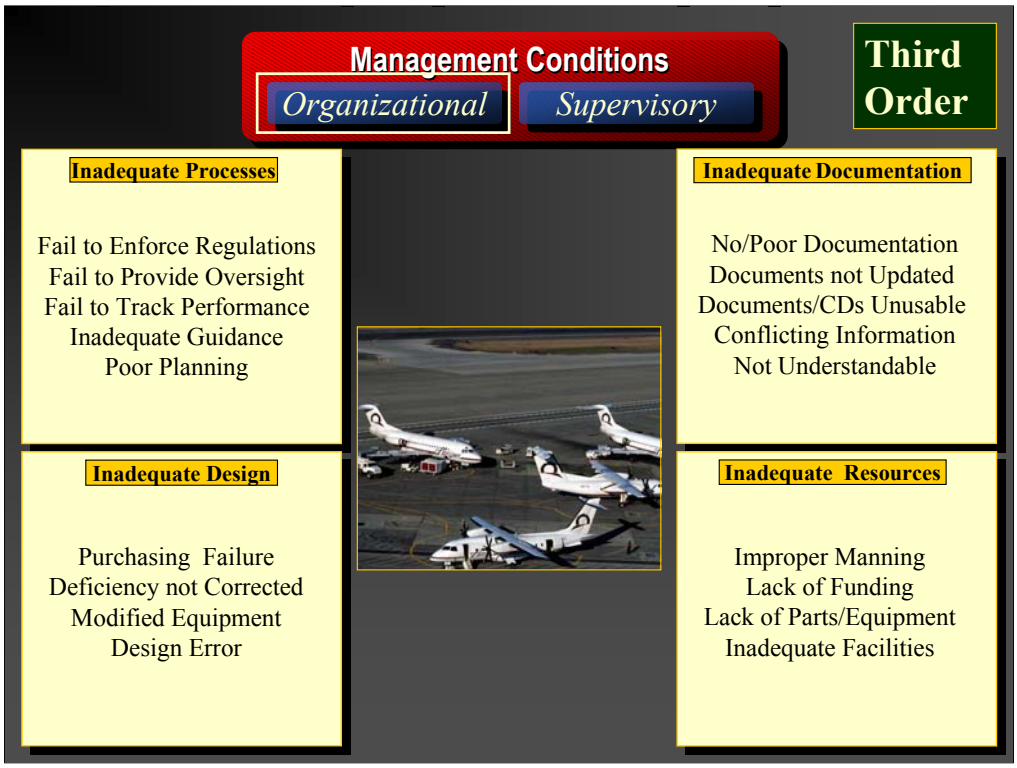
The **Second Order factors (shown in Blue)** provides the further identification needed to isolate the First Order factors into workable categories for error classification and prevention.

And the **Third Order factors (shown in Green)** provide sufficient levels of identification to classify all levels of errors, incidents, and accidents. The Third Order factors provide the most utility for error-type preventative measures and database trend analysis.

The most effective way to define and display the relationship of First, Second, and Third error categories is to examine each First Order Category independently. (quickly go to next slide)



We will begin by examining the **Management Conditions** First Order**.** (quickly go to next slide)



Under **Management Conditions**, we have both **Organizational** and **Supervisory** Second Order Error Categories.

We will start with the **Organizational** Category. It pertains to the overall organization's processes/documents/designs/resources (above the local level); regulatory agency procedures/rules/inspector resources; and outside organization processes/designs/documents (manufacturers guidelines/bulletins/procedures and design issues).

Facilitator note: Read each term and its example below and then mention some of the additional examples listed in each box on the slide. Encourage discussion from students.

Under the Organizational Second Order, we have the following Third Order Error Categories:

Inadequate Processes Limitations in communication, planning, procedures and directives within and between organizations and their departments

Inadequate Documentation A manual omits a step in a maintenance procedure; information is unavailable, conflicting, not current or confusing

Inadequate Design The poor layout of systems and components inhibit maintenance and inspections

Inadequate Resources Insufficient funding, manpower, tools, parts and equipment to perform maintenance effectively and safely

NOTE: The descriptions given, and the examples shown on these slides, are just that . . . examples. The purpose of this presentation is to establish a knowledge and understanding of the HFACS-ME Categories, not restrict their use to only a handful of scenarios.

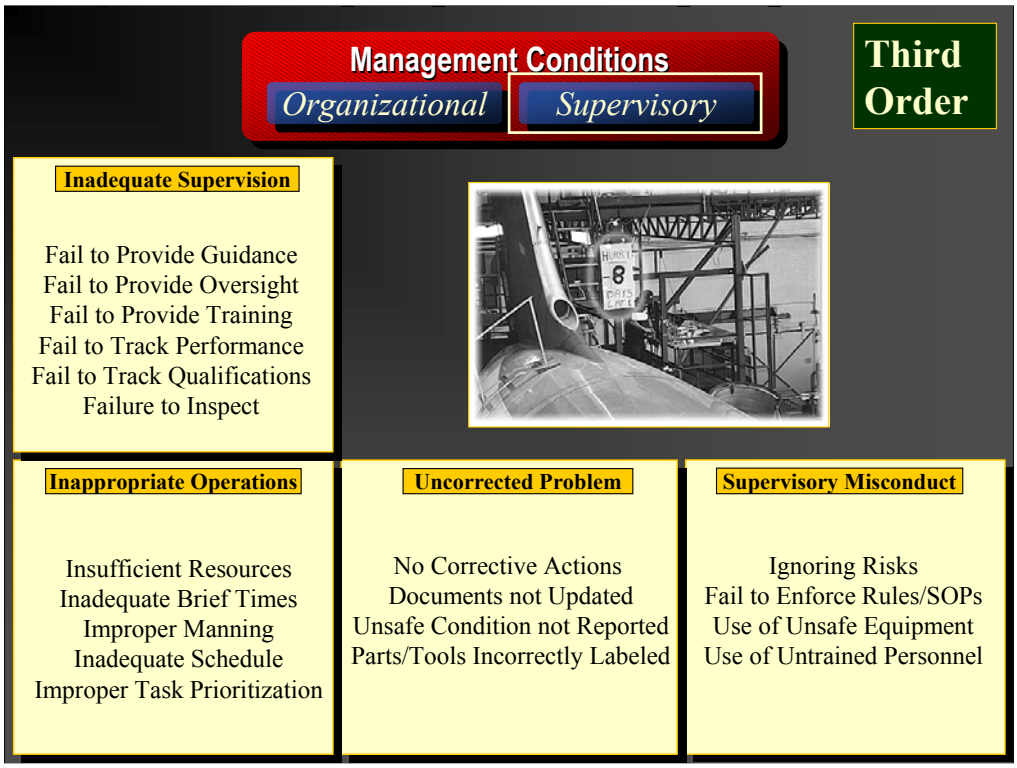


Photo: Retrieved from FAA Smart Center at http://hfskyway.faa.gov

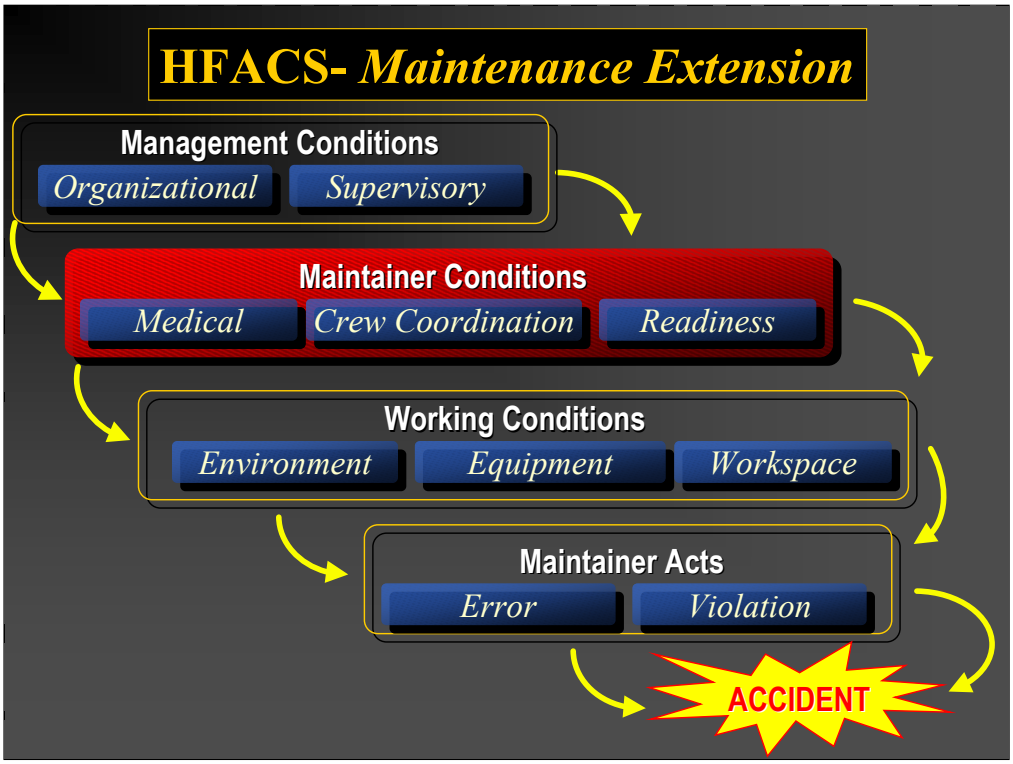
<u>And under the Supervisory Second Order of Management Conditions (local level), we have these Third Order Error Categories</u>:

Inadequate Supervision A supervisor who does not ensure that maintenance personnel are wearing required personal protective gear

Inappropriate Operations A supervisor who directs a maintainer to perform a task without considering risks, such as driving a truck through a hangar

Uncorrected Problem A supervisor who neglects to correct maintainers who routinely bend the rules when they perform a common task

Supervisory Misconduct A supervisor who willfully orders a maintainer to work on an aircraft without proper safety gear or appropriate tools in violation of procedures



Maintainer Conditions, the conditions that uniquely affect individual maintainers, are separated into **Medical, Crew Coordination** and **Readiness Categories.**

(Again advise students to follow along with their copy of the HFACS-ME Framework slide).

(quickly go to next slide)

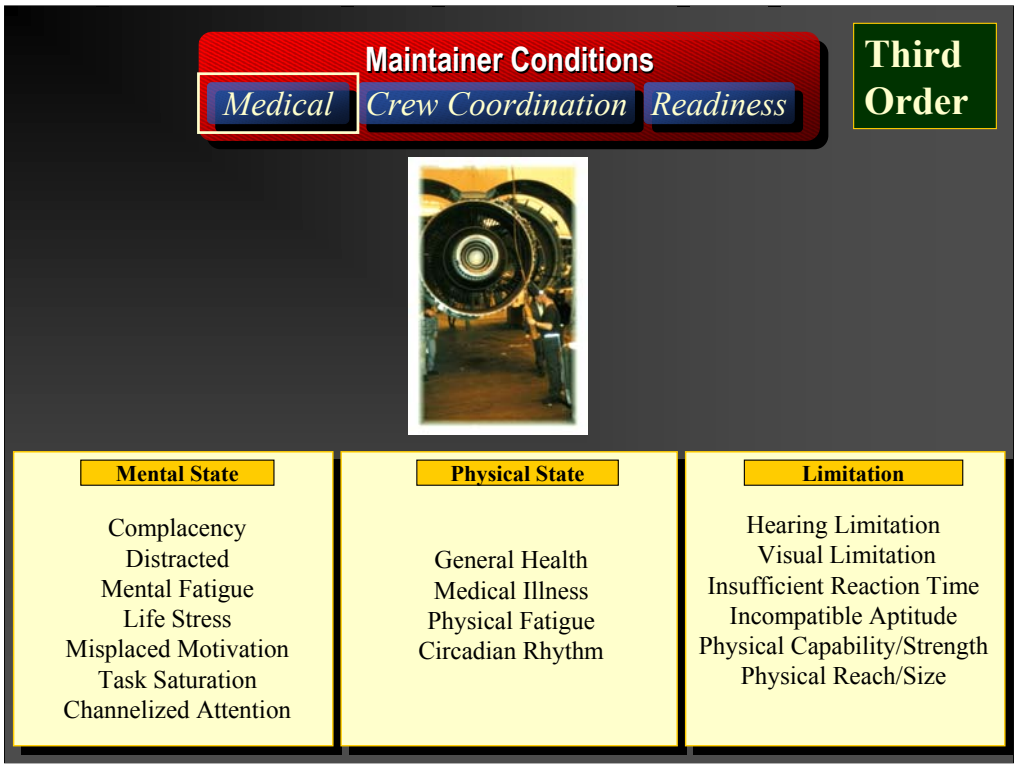


Photo: Retrieved from FAA Smart Center at http://hfskyway.faa.gov

The **Medical** Third Orders are based on an individuals **Mental and Physical** abilities (and **Limitations**) to perform a task at a certain time.

They include:

Mental State A maintainer with life stress cannot focus on a maintenance action

Physical State A maintainer who worked for 20 hours straight and suffers from fatigue

Limitation (Physical) A maintainer who is short cannot visually inspect an aircraft component before it is launched

Note: Medical Factors are not reported adequately

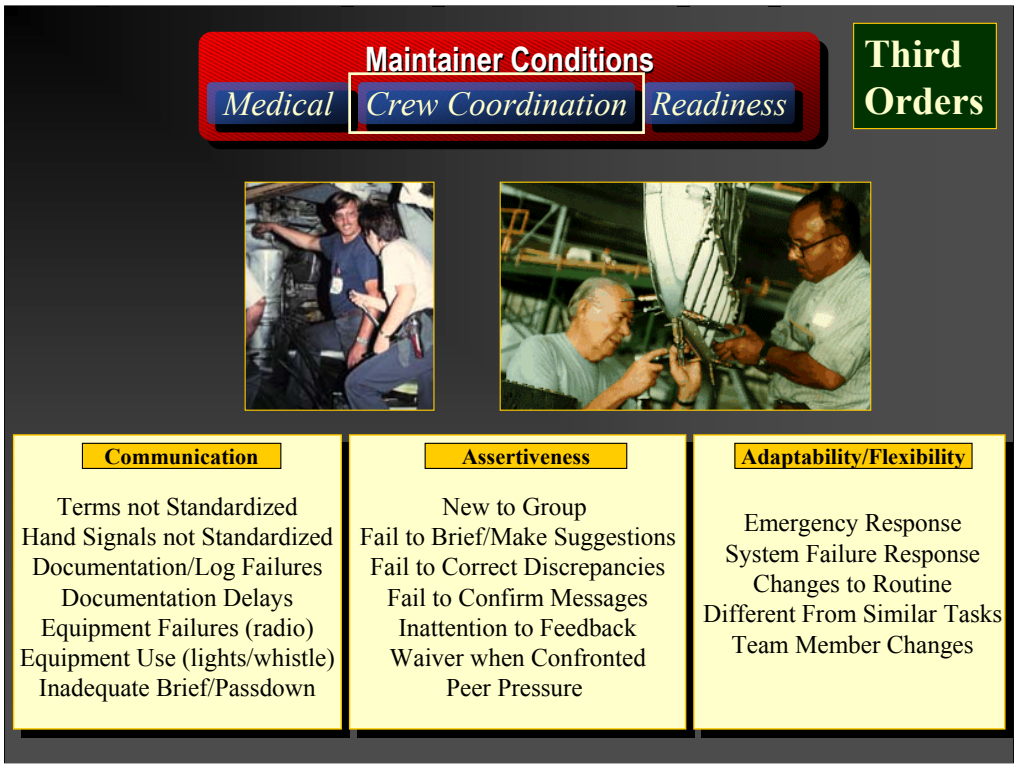


Photo 1: Retrieved from "Human Factors Aviation Maintenance" at http://hfskyway.faa.gov/cd-rom/Maint_hf.ppt

Photo 2: Retrieved from http://hfskyway.faa.gov/

Crew Coordination factors include problems in:

Communication A maintainer who leads a taxiing aircraft into another due to improper hand signals

Assertiveness A maintainer who performs a task, not in accordance with standard procedures, because the maintainer was overly submissive to a superior

Adaptability/Flexibility A maintainer who downplays a downing discrepancy to meet the flight schedule

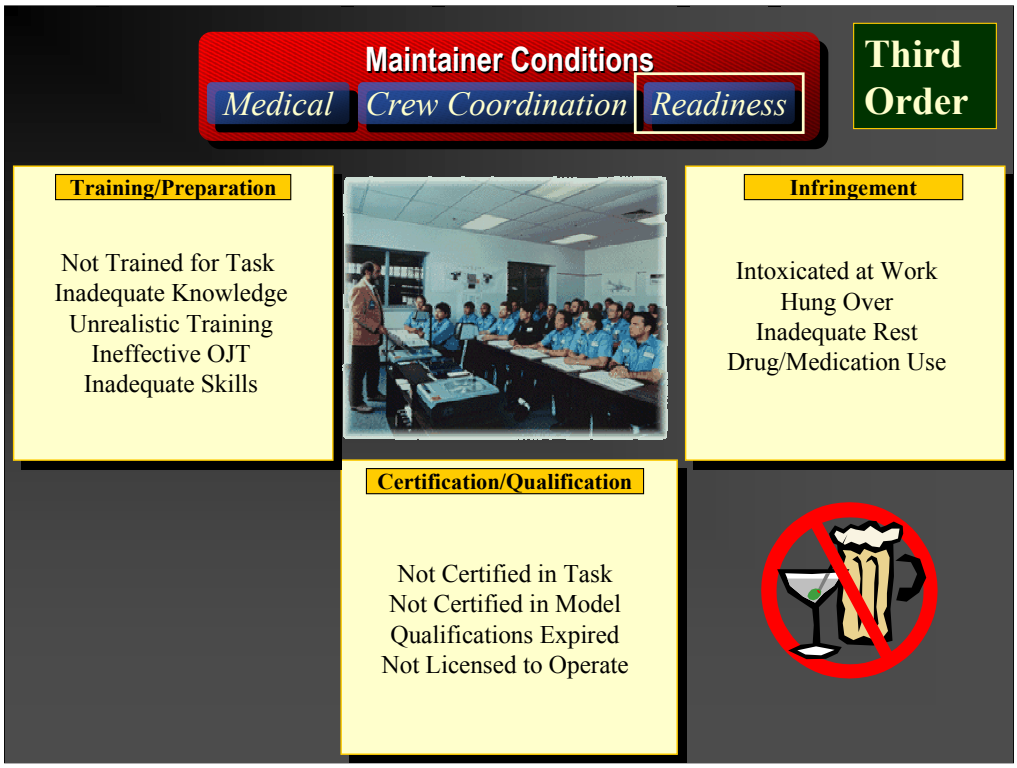


Photo: Retrieved from FAA Smart Center at http://hfskyway.faa.gov

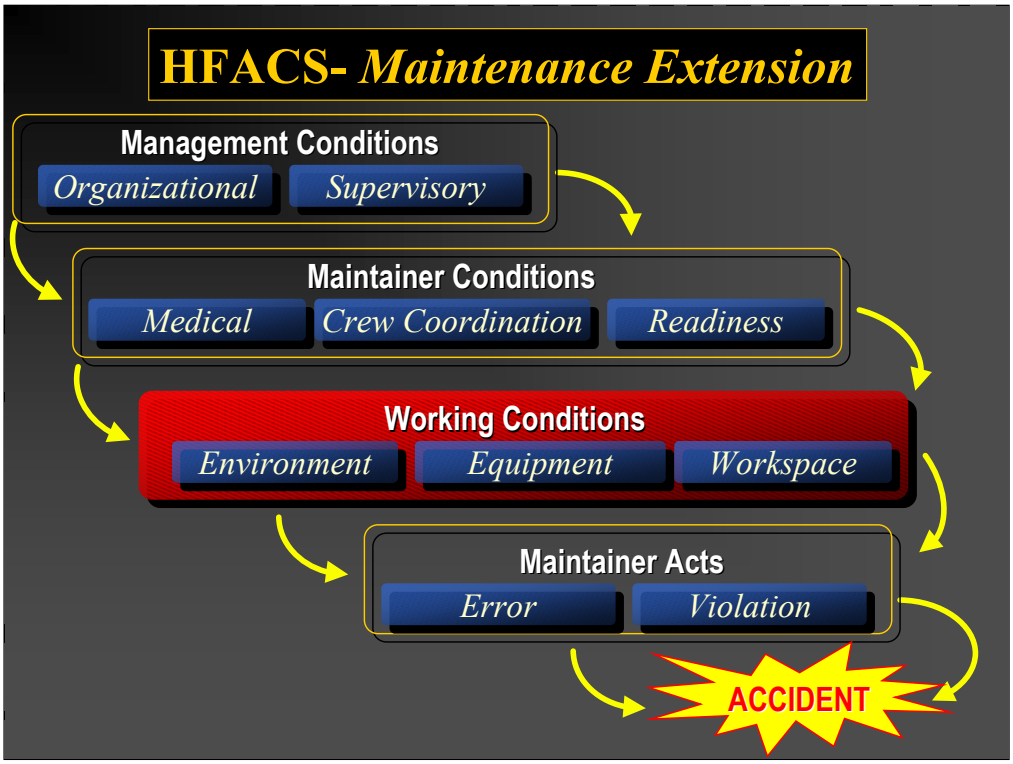
<u>And the last Maintainer Conditions category is Readiness. Its Third Orders involve</u>:

Training/Preparation A maintainer who is working on an aircraft skipped the requisite OJT evolution

Certification/Qualification A maintainer who engages in a procedure that he or she has not been qualified to perform

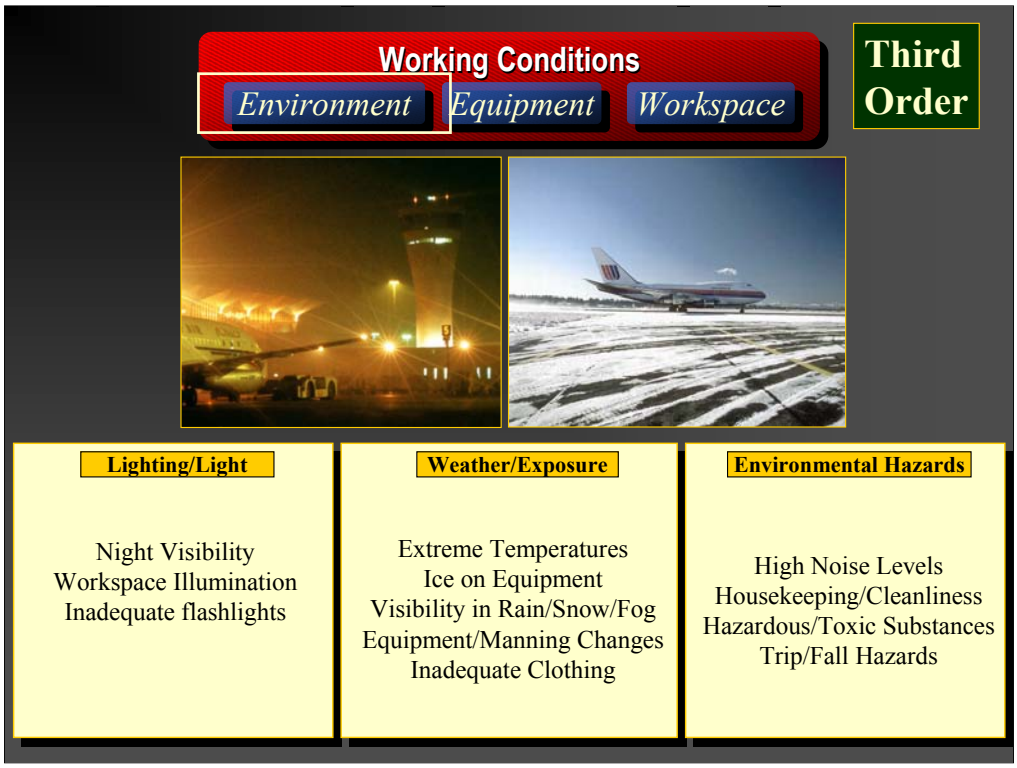
Infringement A maintainer who is intoxicated on the job.

Note: Readiness Factors are also not reported adequately.



Let us now examine the **Working Conditions** First Order Error Category breakdown.

(quickly go to next slide)



Working Conditions have Second Order Error Categories of **Environment, Equipment, and Workspace factors.**

<u>The Environment Second Order can be further broken down into the following Third Orders</u>:

Lighting/Light A maintainer who is working at night on the flight line does not see a tool he left behind; poor hangar lighting increases chances of FOD being undetected

Weather/Exposure A maintainer who is securing an aircraft in a driving rain fails to properly chock the aircraft; ramp procedures rushed (and missed) due to extreme cold

Environmental Hazards A maintainer who is working on the aircraft during rain showers slips from the aircraft; other environmental hazards include workplace environments where clutter, oil spills, and other slip/trip hazards exist; high noise levels/fumes/odors impair worker performance

Note: Environmental Factors are often not adequately reported.

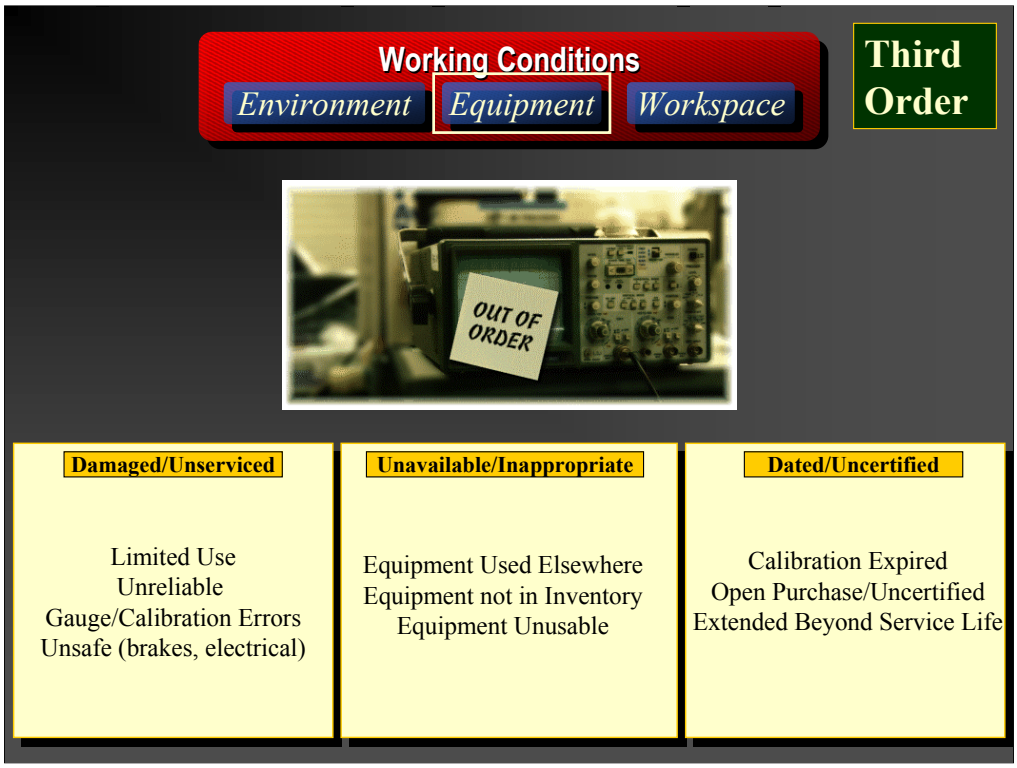


Photo: Retrieved from FAA Smart Center at http://hfskyway.faa.gov

Equipment Third Orders are:

Damaged A maintainer who is using a defective test set does not pre-check it before troubleshooting

Unavailable/Inappropriate A maintainer who starts working on landing gear without a jack because all are being used

Dated/Uncertified A maintainer who uses an old manual because a CD-ROM reader is not available

Note: Tools and **Equipment** factors are also not adequately reported.

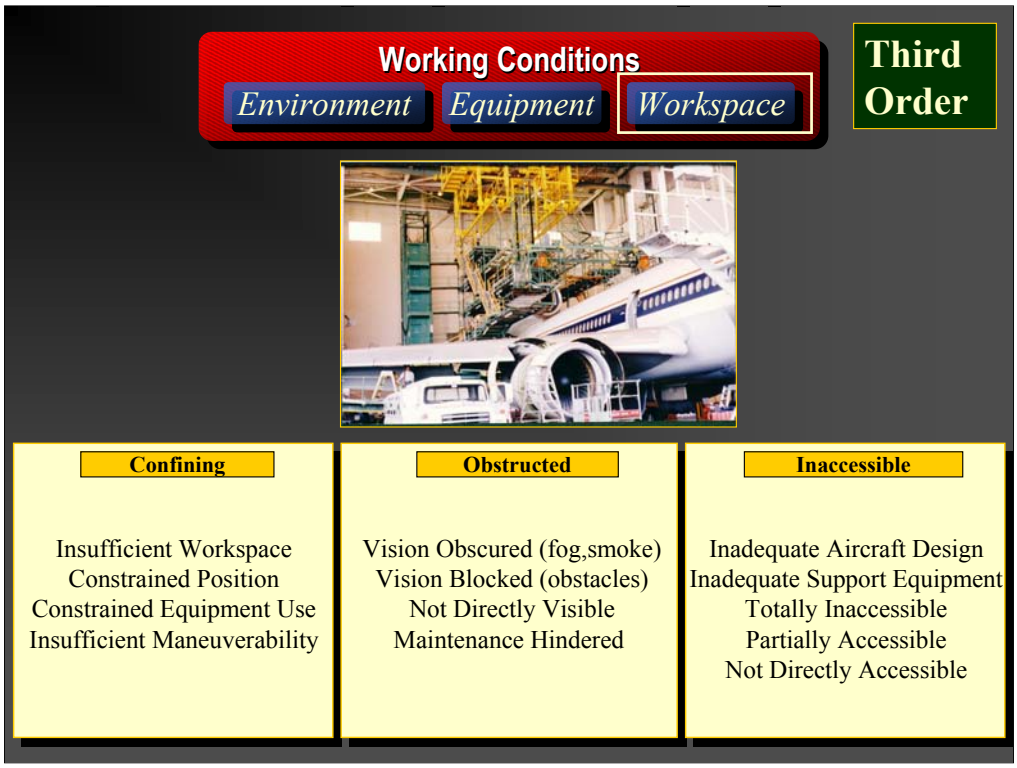


Photo: Retrieved from "Human Factors Aviation Maintenance" at http://hfskyway.faa.gov/cd-rom/Maint_hf.ppt

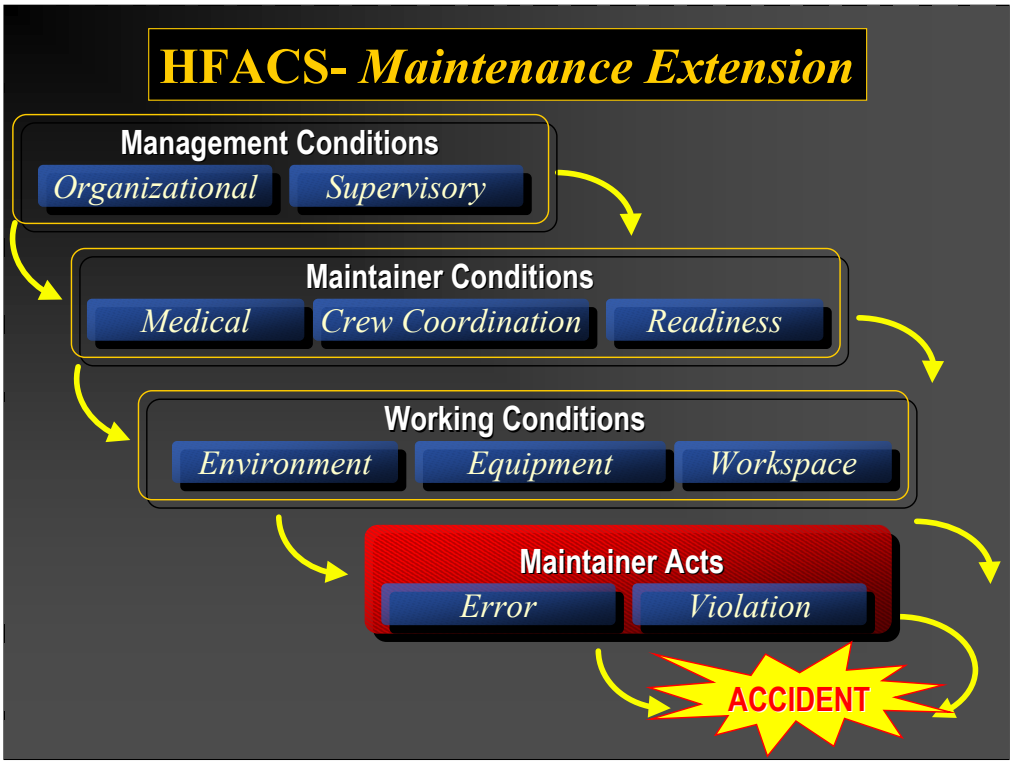
And finally, Workspace factors can be separated into these Third Order Error Categories:

Confining A maintainer working in a fuel cell cannot access a specific cell component

Obstructed A maintainer is spotting an aircraft with his view obscured by fog/vehicles

Inaccessible A maintainer is unable to perform a corrosion inspection in an area that is beyond reach

Note: Workspace factors are also not adequately reported.



The final category is **Maintainer Acts**, which include **Errors** (mistakes) and **Violations** (willful acts). (quickly go to next slide)

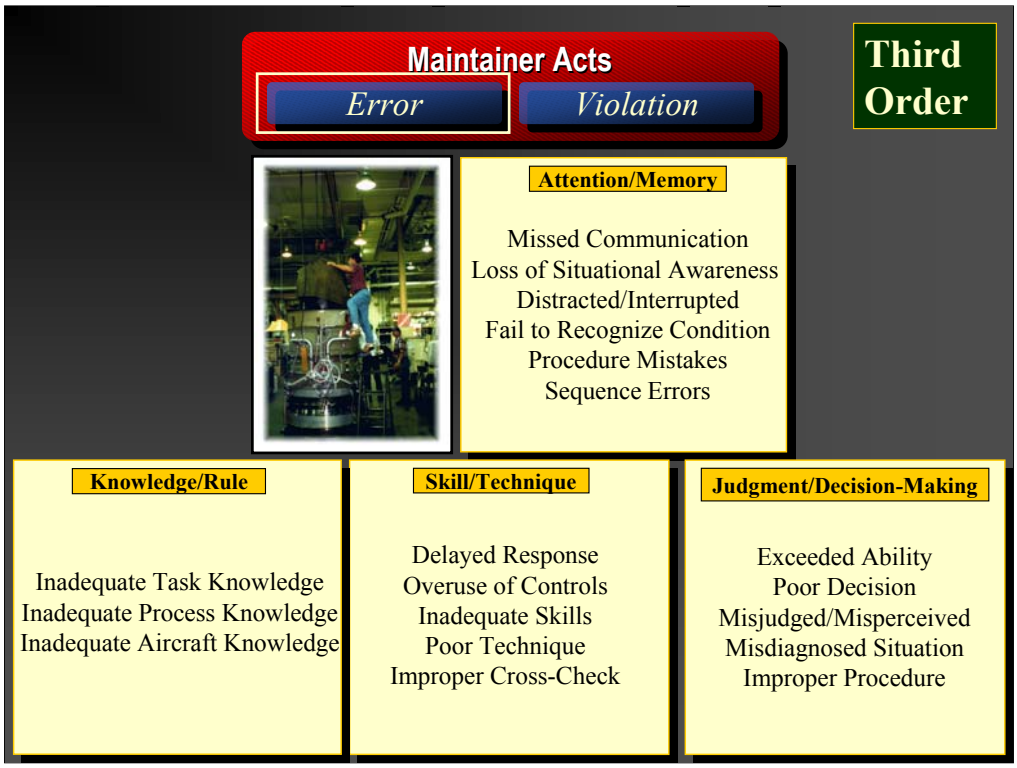


Photo: Retrieved from FAA Smart Center

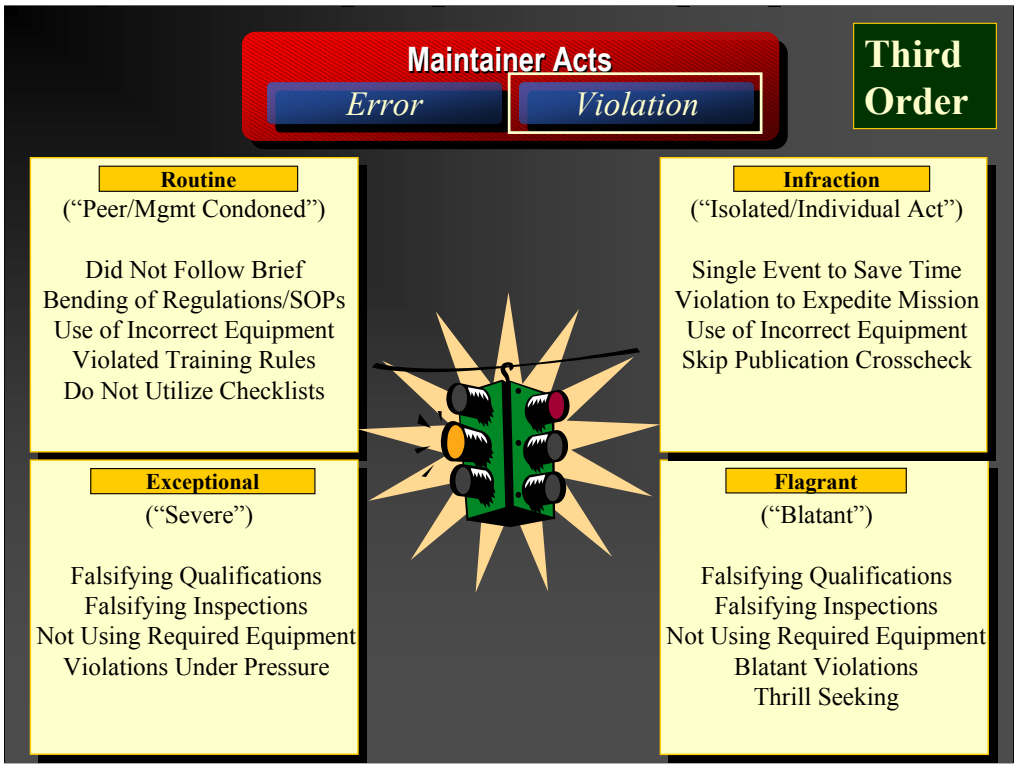
Maintainer Errors are of the following Third Order types:

Attention/Memory A maintainer who misses a hand signal and backs a forklift into an aircraft; or a maintainer who is very familiar with a procedure may reverse steps in a sequence

Knowledge/Rule Based A maintainer who inflates an aircraft tire to a pressure required by a different aircraft

Skill/Technique A maintainer who roughly handles a delicate engine valve will cause undue damage

Judgment/Decision-Making A maintainer who fails to make appropriate decisions due to limited information, inadequate preparation, or perceived pressure to perform; or misjudging the distance between a vehicle and a wingtip



There are also several types of **Maintainer Violations.**

The Third Order categories are based upon frequency, intent, and supervisory involvement:

Routine A maintainer engages in practices, condoned by management and peers, that bend the rules

Infraction A maintainer strays from accepted procedures to save time (isolated act, not routine)

Exceptional A maintainer under perceived pressure omits an inspection and signs off an aircraft (a direct and severe violation, but no intent to damage equipment/cause injuries)

Flagrant A maintainer who willfully breaks standing rules, disregarding the consequences (no concern for safety)

Case Study: MD 88 Uncontained Engine

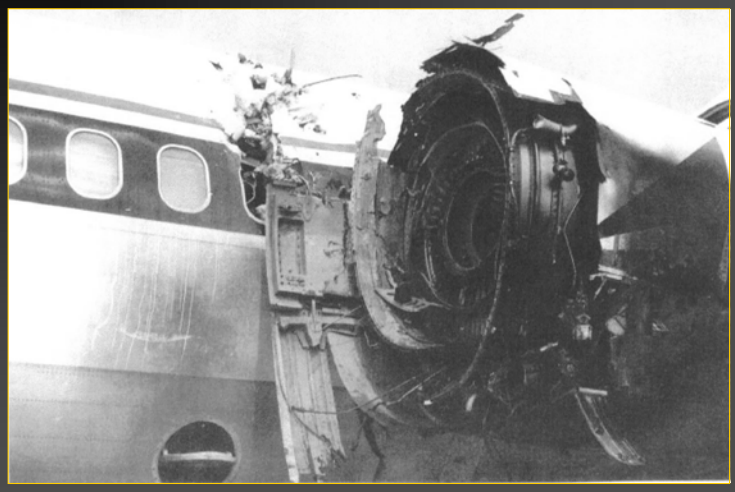


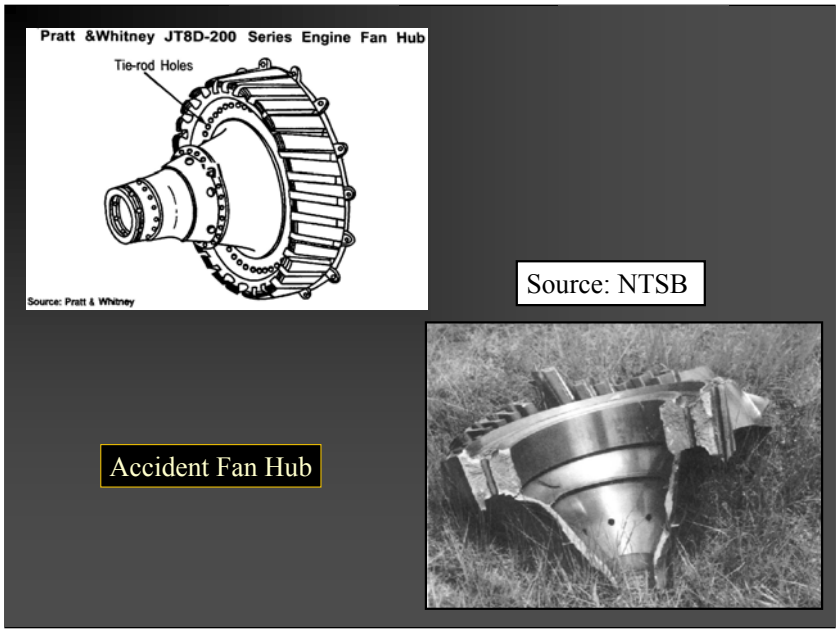
Photo: Retrieved from NTSB website http://www.ntsb.gov

We will now apply HFACS-ME to an existing NTSB report:

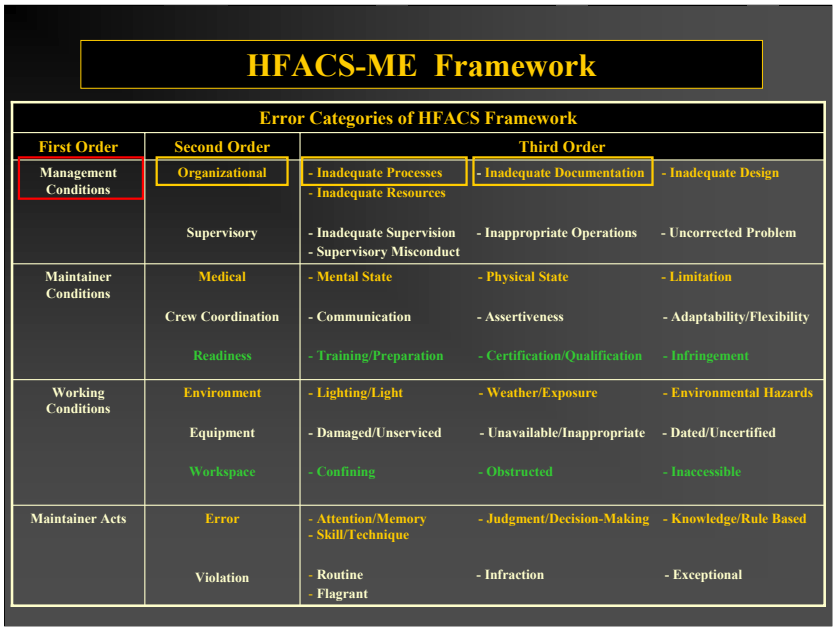
This accident resulted in the loss of two passengers' lives and injuries to five others. It is a single example of a recurrent hazard – the failure of critical rotating components.

You will notice that this accident also involves fatigue-related cause factors. Although no two accidents are exactly alike, they often have similar cause factors, such as component fatigue. It is essential that we thoroughly identify individual cause factors if we are to be successful in limiting their potential to cause future accidents.

Facilitator: Have the students read the Case Study in the Student Guide at this time.



As the students begin reading, draw attention to this slide to show the accident hub and the illustrated location of the tie-rod holes.



Let us first use HFACS to classify the Management Conditions that preceded this event:

Were there Organizational factors?

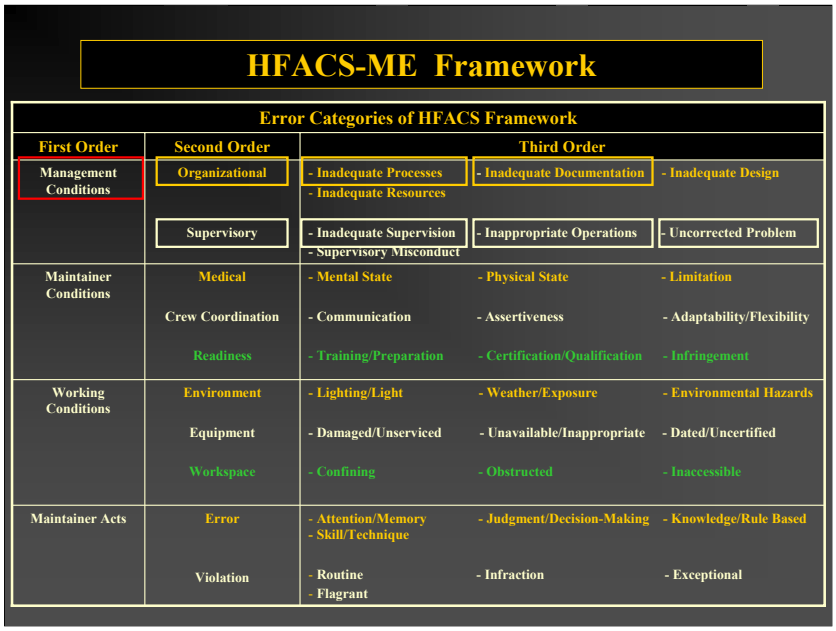
Inadequate Processes Yes. Drilling methods and QA; Blue Etch Anodize inspection interpretation; hot water rinse and dye penetrant application; use of 3-power magnifying glass and glaring lights for inspection of tie-rod holes; FPI training is accomplished but remains inadequate; lack of inspection status and time-tracking; lack of redundant inspections; FAA failure to implement eddy current criteria.

Inadequate Documentation Yes. Blue Etch Anodize inspection rejection criteria and templates; non-factor hazard of airline criteria for a maintenance "discrepancy" and "maintenance irregularity".

Inadequate Design No.

Inadequate Resources No.

(Supervisory factors on next note page)



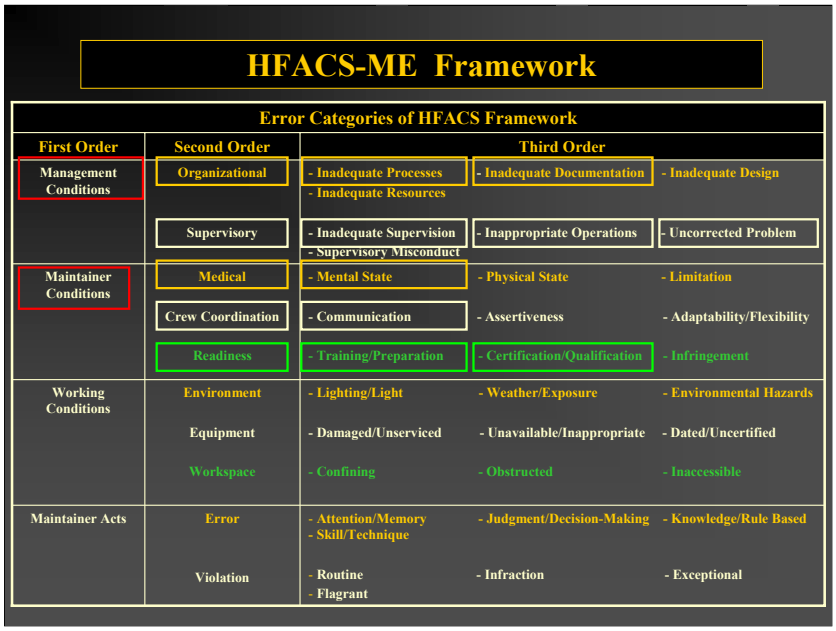
Supervisory?

Inadequate Supervision Yes. Volvo tie-rod drilling failures; Volvo BEA accuracy; Delta FPI processes; hot water rinse temperature monitoring.

Inappropriate Operations Yes. Using "group knowledge" for inspection tracking vice timing/status boards; using "feel" to determine hot water rinse temperature; poor QA on part cleaning; excessive handling of parts during FPI process.

Uncorrected Problem Yes. Inadequate cleaning of parts (prior to inspections) required frequent returns for additional cleaning while management failed to change training or adequately correct performance.

Supervisory Misconduct No.



Maintainer Conditions:

Medical?

Mental State Yes. Inspectors/supervisors had a low expectation of finding cracks and may have been less vigilant; tedious FPI process averaged 40 minutes to 2 hours.

Physical State No. Report stated that the FPI inspector was in good health and worked stable hours.

Limitation No. There were no physical characteristics noted that would affect any maintenance/inspection actions.

Crew Coordination?

Communication Yes. Delta inspection process relied upon "group knowledge" for tracking.

Assertiveness No.

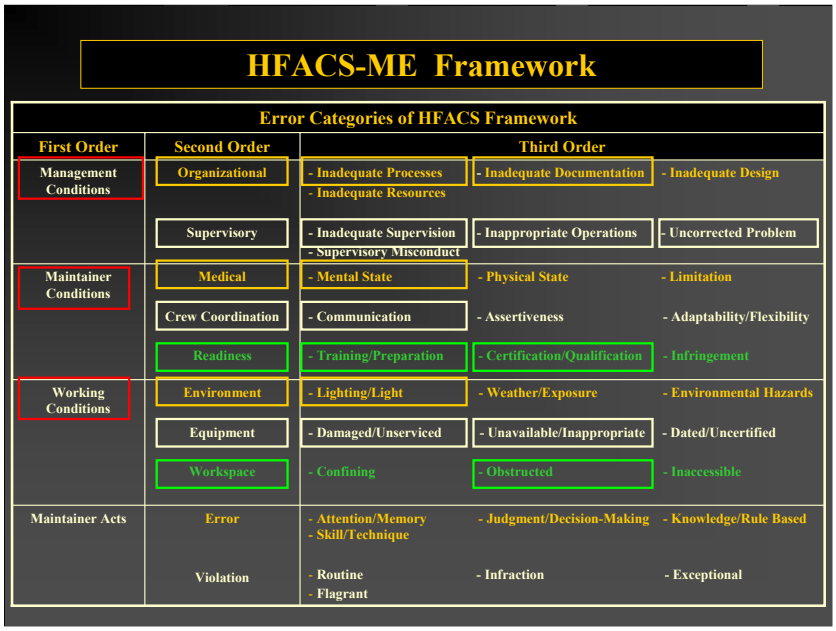
Adaptability/Flexibility No.

Readiness?

Training/Preparation Yes. Although the inspectors were trained, the entire standard of training is inadequate and needs to be addressed. Parts cleaning teams were not trained adequately.

Certification/Qualification Yes. (Same as above).

Infringement No.



Working Conditions?

Environment?

Lighting/Light Yes. Tie-rod holes were not illuminated adequately for inspection.

Weather/Exposure No.

Environmental Hazards No.

Equipment?

Damaged/Unserviced Yes. Drill failures at Volvo.

Unavailable/Inappropriate Yes. Magnifying glass/light for inspection was inadequate compared to a borescope.

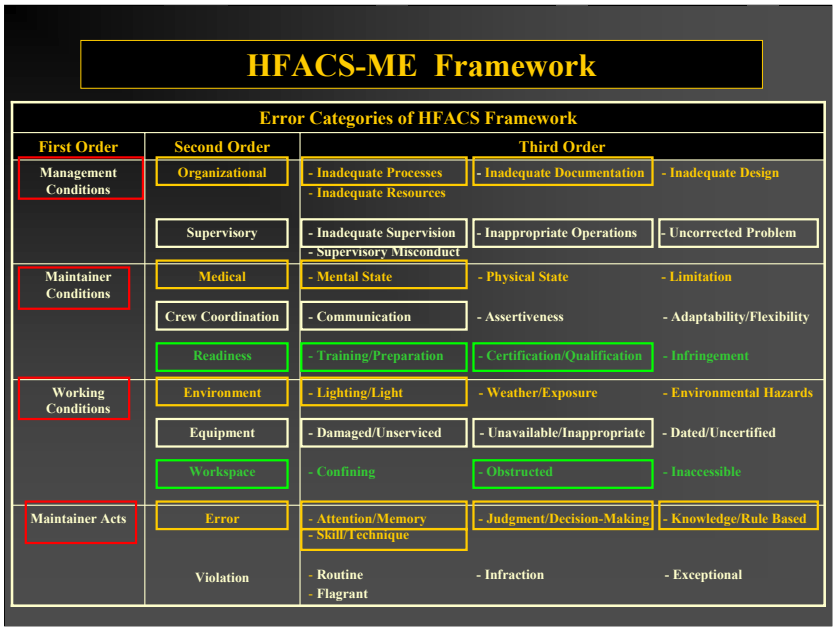
Dated/Uncertified No.

Workspace?

Confining No.

Obstructed Yes. Cracks within tie-rod holes were not visible; inspection areas may be missed by hand/cable placement or by rubbed off dye.

Inaccessible No.



Maintainer Acts?

Error?

Attention/Memory Yes. Inspection scan breakdown and possible missed areas due to distractions and lack of progress tracking.

Judgment/Decision-Making Yes. BEA/FPI "passed" inspections.

Knowledge/Rule Based Yes. Although trained, the industry-wide training standard was inadequate.

Skill/Technique Yes. BEA/FPI scan and overall inspection. Part cleaning/preparation.

Violations?

Routine No.

Infraction No.

Exceptional No.

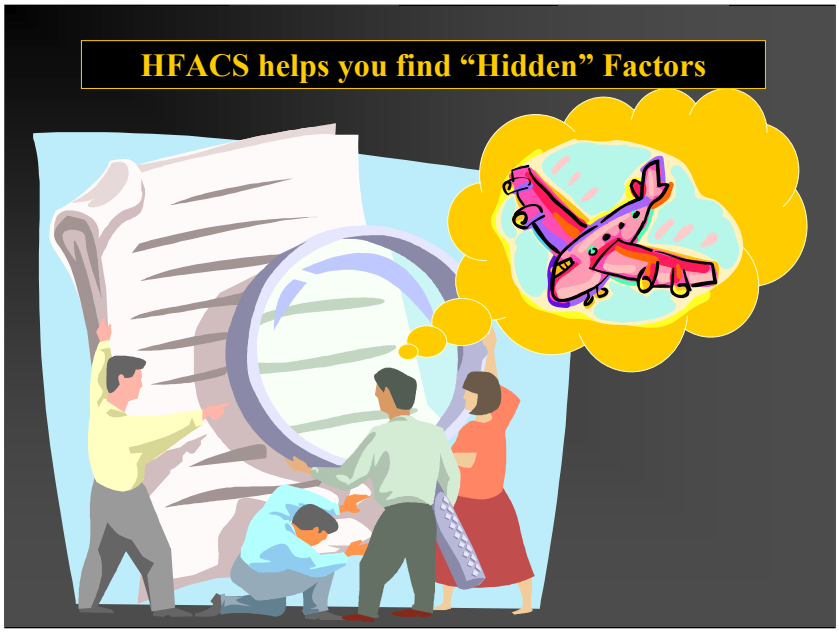
Flagrant No.

Hopefully you are now convinced that HFACS does provide an excellent method of analyzing both accidents and incidents…and it can be used to reevaluate existing reports without the need for a new investigation! Using this framework as a "standard" will also improve database entries and trend analysis.

(go to next slide)

Accident: Delta Air Lines, Flight 1288, N927DA, uncontained engine failure at Pensacola, Florida on July 6, 1996.

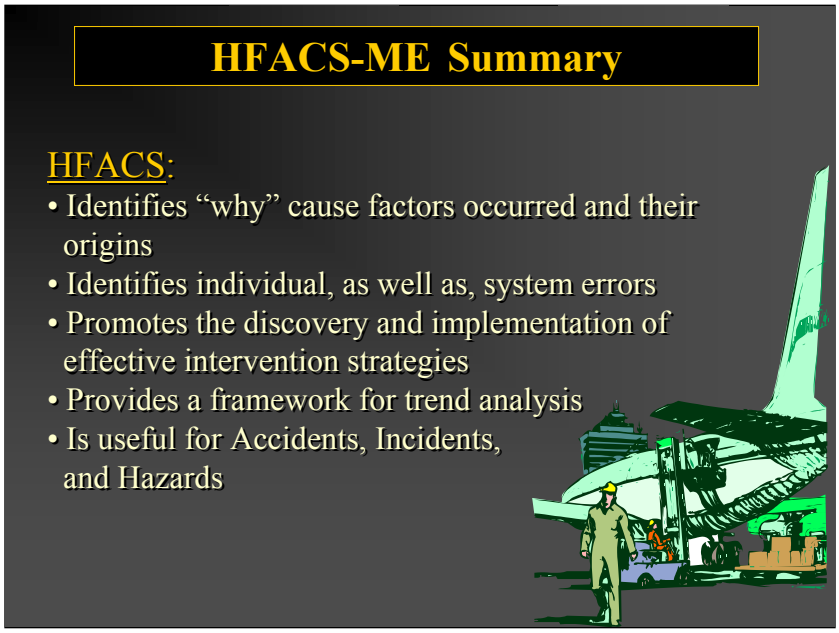
Reference: NTSB/AAR-98/01. Available at http://www.ntsb.gov.



So, did HFACS again help us to investigate and understand additional factors and hazards that were not apparent from the NTSB report? Yes.

Even if HFACS only helped us discover one extra "minor" factor (and there really is no such thing because factors work together "like big and small dominoes" to cause accidents!), then wouldn't it be worth using for all maintenance related accidents, incidents, and hazards?

By the way, differences in similar accidents do not necessarily lessen the possibility of future accidents, they may instead prove that those type of accidents can occur even with or because of those different factors. This knowledge should encourage mechanics, supervisors, managers, and CEO's to take an even closer look at their policies and procedures.



As we end this presentation, we hope that you realized the potential benefits of using the HFACS-ME Framework. We have seen during these case studies that it is a significant improvement over previous methods.

HFACS:

-Provides organizations (as well as outside investigators) a means to identify the origins of accident or incident cause factors and the reasons "why" they occurred

-The First and Second Order categories show the depth of the problem by identify individual maintenance errors within the context of the organizational system

-The Third Order categories provide a level of classification that allows direct and effective intervention strategies to be created

-The use of HFACS on both previous and future investigation reports will provide an organization with an excellent template for use in trend analysis to prevent even more accidents, incidents, and injuries

-And of course, HFACS can be used to investigate and analyze accidents, incidents, and even hazards.

HFACS-ME offers maintenance organizations the ability to conduct EFFECTIVE investigations and analysis to determine those corrective actions.

It is up to the organizations and the regulators to effectively share that information.

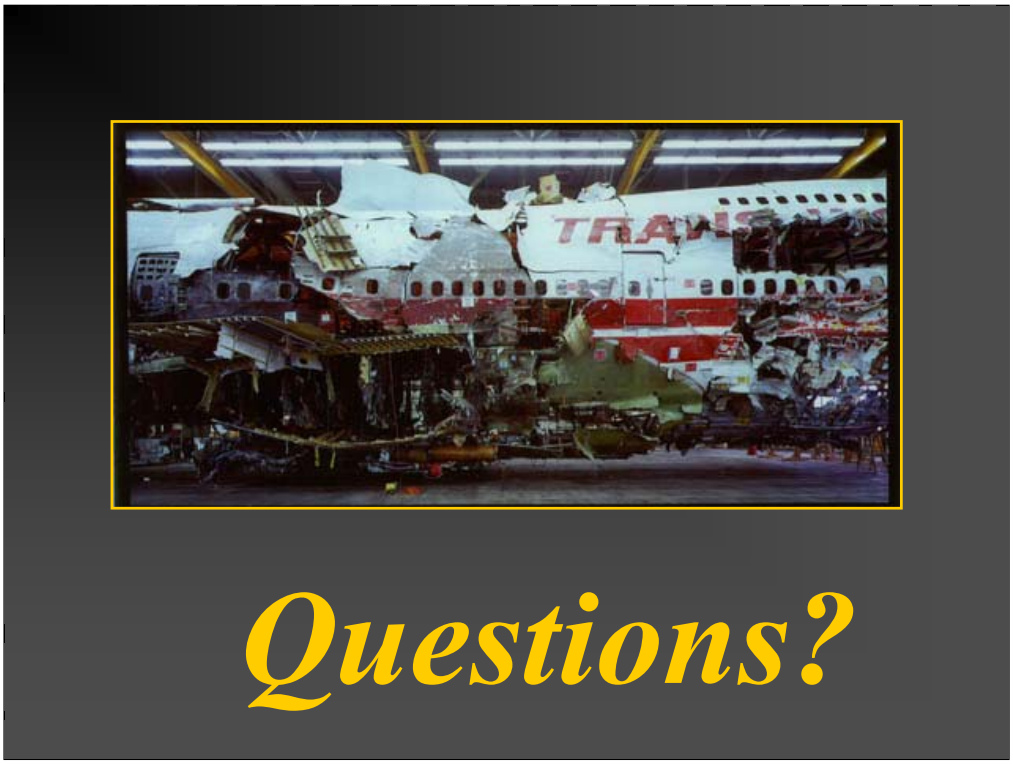


Photo: NTSB website at www.ntsb.gov (TWA 800 Explosion)

This concludes the third HFACS-ME presentation. You now have a better understanding of the individual error categories and their interrelationships in an accident's chain of events.

Questions?